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GB 0548965 GB 0538994 GB 0458820
GB 0543336

(58) Field of search
H1Q

(54) **Antenna arrangements**

(57) An antenna arrangement is described for receiving transmissions on a ship, or other mobile, from a geostationary satellite or the like, and includes means for compensating for multi-path interference caused by reflection from the sea. The arrangement has two antenna elements 20,22 which are mounted on a screw-jack arrangement 40 which can be adjusted by a motor 42 so as to alter the separation D. This varies the position of the nulls in the response of the elements. Separation D is adjusted according to the geographical position of the ship relative to the satellite so as to position a null in line with the path of the reflected signal. In order to provide additional compensation for the instantaneous changes in attitude of the ship due to the motion of the sea, a phase shifter 34 is provided. This is adjusted by transducers sensitive to the ship's attitude and thus alters the angle of the response of the antenna arrangement relative to the two elements 20,22. The phase shifter 34 may advantageously be adjusted by a closed-loop feedback arrangement which monitors the received signal and produces a correction signal dependent on any fading.

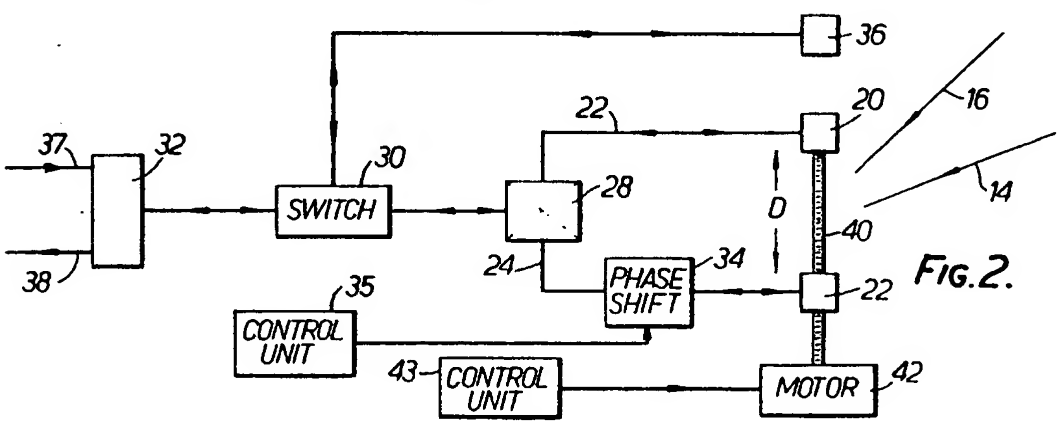

FIG.2.

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The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

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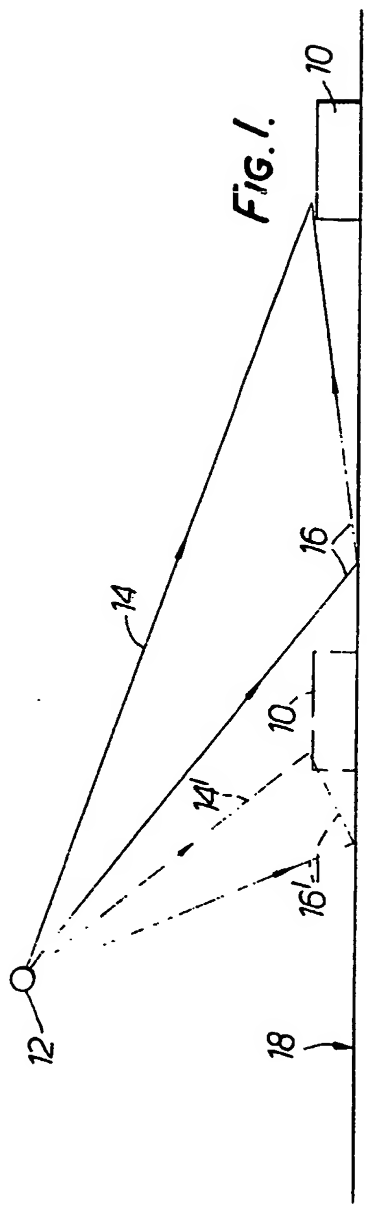

Fig.1.

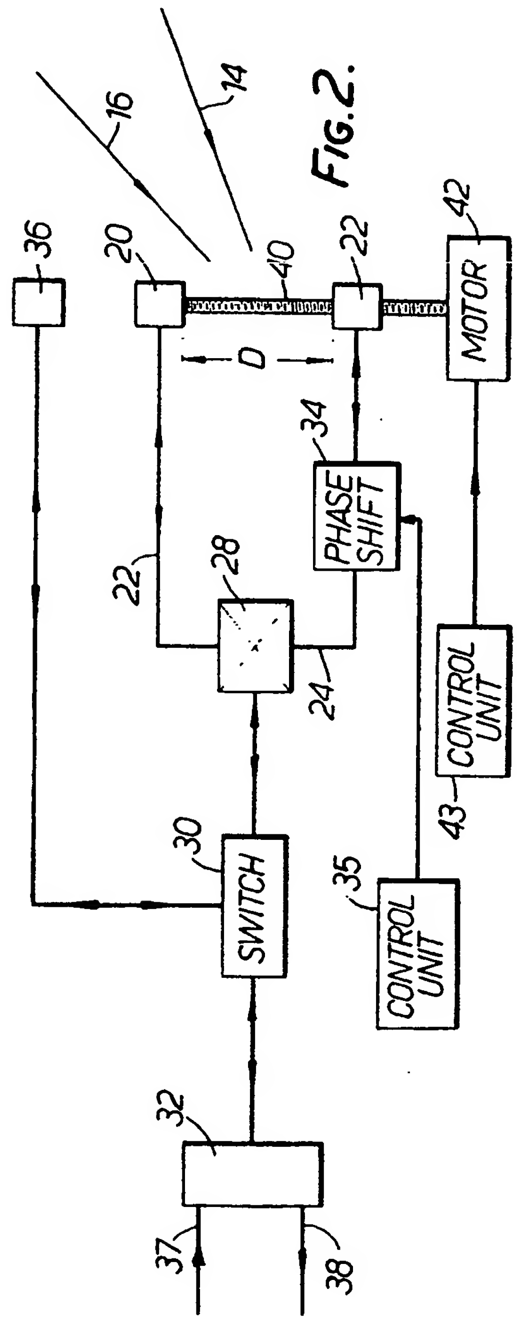

Fig.2.

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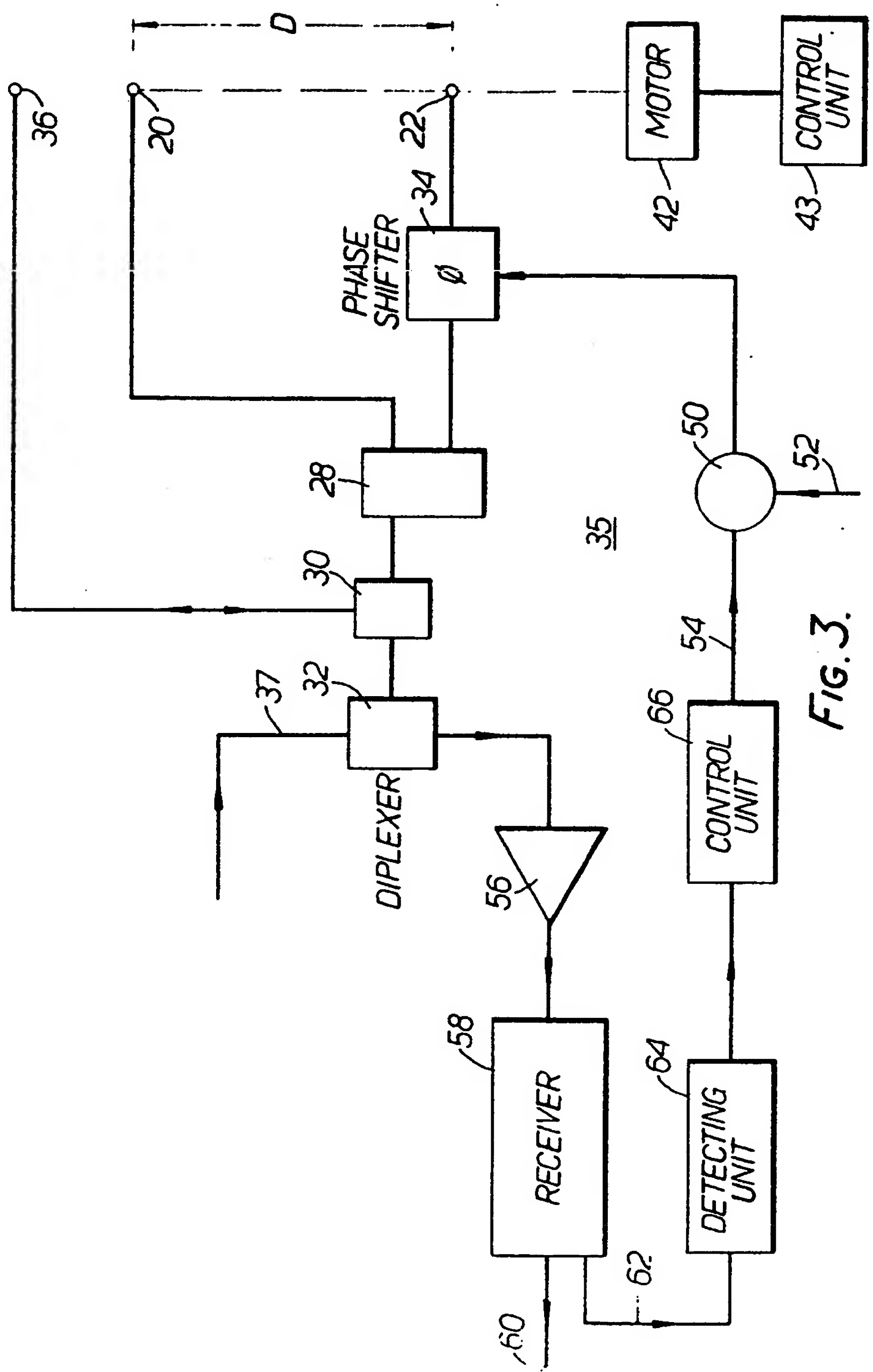
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FIG. 3.

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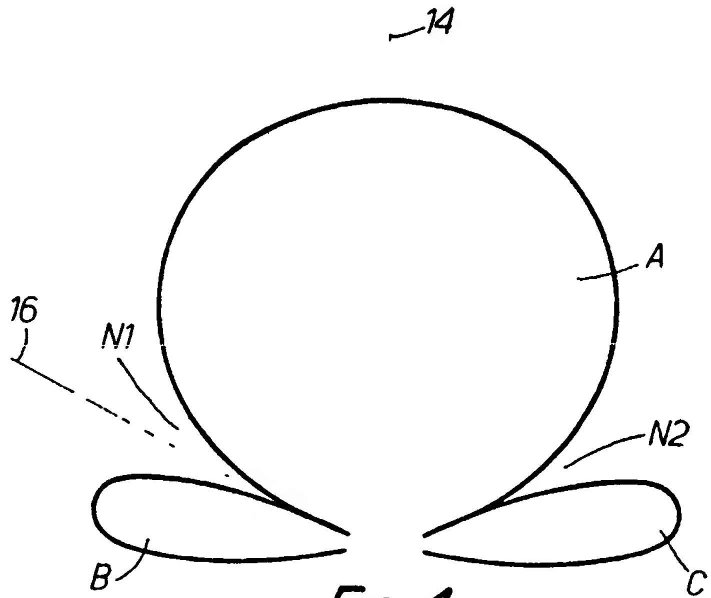

FIG. 4.

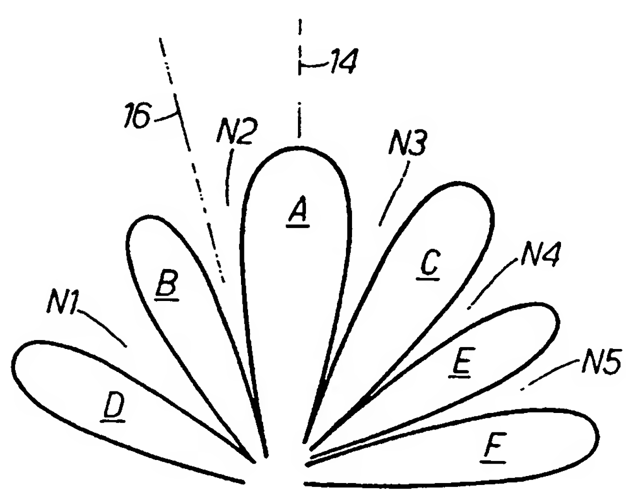

FIG. 5.

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SPECIFICATION

Improvements in and relating to antenna arrangements

The invention relates to antenna arrangements. More specifically, the invention relates to antenna arrangements for facilitating radio communication between a transmitter and a receiver under circumstances in which variable multi-path interference can occur. The invention is thus applicable to radio communication involving a mobile transmitter/receiver. One particular though not limiting application of an embodiment of the invention concerns radio communication between a geo-stationary satellite and a mobile, such as a ship, where multi-path interference can occur as a result of interference between the directly received signal and one or more signals received by reflection from the sea.

According to the invention, there is provided an antenna arrangement, comprising a plurality of antenna elements, and driving means for mechanically varying the distance between them whereby to vary the position of the nulls in the response of the antenna arrangement.

According to the invention, there is further provided an antenna arrangement for use on a mobile whose geographical position and whose attitude relative to a transmitter are subject to variation, comprising two antenna elements, driving means operable to vary the physical separation between the antenna elements according to the said geographical position, whereby to adjust the position of a null in the response of the antenna elements so as to bring that null into at least approximate alignment with a path along which undesired radio signals are expected, phase shifting means connected to phase-shift the electrical signal received from one element relative to that received from the other, and adjusting means operative to adjust the said phase shift in dependence on the said attitude, whereby to vary the angle of response of the elements.

Antenna systems embodying the invention will now be described, by way of example only, with reference to the accompanying diagrammatic drawings in which:

Figure 1 illustrates the environment in which the antenna systems may be used;

Figure 2 is a diagram of one of the systems;

Figure 3 is a more detailed circuit diagram corresponding to that of Fig. 2 but also showing control circuitry; and

Figures 4 and 5 show polar diagrams of the antenna systems illustrating their responses.

The systems to be described are primarily, though not exclusively, intended for use on board a ship 10 (Fig. 1) for receiving radio transmissions from a geo-stationary satellite 12. When the ship 10 is in the position illustrated in full line, it will receive the radio signal directly along a path 14. In addition, however, it will receive the radio signal along a second path 16 involving reflection from the surface of the sea 18. Clearly, the paths 14 and 16 will have different lengths and interference between the signals received along these two paths will occur causing fading and unsatisfactory reception.

When the ship 10 is in the position shown dotted, the direct and reflected signal paths will be as shown at 14′ and 16′, and again interference and resultant fading will occur.

Because the ship 10 moves relative to the satellite 12, therefore, the problem of multipath interference cannot be overcome by simple design of the antenna system (so as to maximise reception of the direct radio signal and to minimise reception of the reflected radio signal).

As shown in Fig. 2, one of the antenna arrangements, for mounting on the ship 10, comprises two main antenna elements 20 and 22. These may be of any suitable type, for example "Lindenblad"-type phased array elements. They are connected via lines 24 and 26 through a coupler 28 and a switch 30 to a diplexer 32, the connection 24 including an adjustable phase shifting unit 34 which is controlled by a control unit 35.

The switch 30 enables the elements 20 and 22 to be disconnected from the diplexer and an auxilliary antenna element 36 connected instead.

The diplexer 32 has connections 37 and 38 which are respectively connected to a radio transmitter and a radio receiver.

The antenna elements 20 and 22 are mechanically arranged so that their physical separation, D, may be mechanically adjusted. Purely by way of example, Fig. 2 illustrates the elements 20 and 22 as being connected by a screw-jack type of arrangement 40 which is driven by an electric motor 42 under control of a control unit 43. The arrangement is such that rotation of the motor in one direction increases the distance D while rotation in the opposite direction decreases D.

The form of the polar diagram of a multi-element antenna arrangement depends (among other factors) on the separation between the elements. Thus (considering a two-element antenna arrangement for simplicity), the response will normally take the form of a plurality of lobes A,B,C (Fig. 4) separated by nulls N1 N2 . . . , the nulls being positioned where the different path lengths to the two elements 20,22 are such that cancellation occurs. It will be apparent that the size of the lobes A,B,C and the resultant angular positions of the nulls N1,N2 . . . will depend on the separation between the elements 20, 22. Thus, Fig. 4 shows the form of response curve when the distance D is relatively great, while Fig. 5 shows the corresponding curve

when the distance D is relatively small. In accordance with the feature of the invention, therefore, the distance D is varied, by means of the motor 42 (Fig. 2) and under control of control unit 32, in accordance with the position of the ship 10 in relation to the satellite 12, so as to maximise the response to the radio signal received along the direct path 14 (Fig. 1) and to minimise the response to the radio signal received along the reflected path 16. More specifically, therefore, the distance is adjusted so as to position one of the nulls in line with the reflected path 16 and one of the lobes in alignment with the direct path 14, as shown dotted in Figs. 4 and 5.

It will be appreciated that the position of the satellite 12 in relation to the position of the ship 10 will be known quite accurately, and it is thus a simple matter to drive the motor 42 until the separation D between the elements 20,22 provides the desired response. For example, the distance D could simply be adjusted to a predetermined value according to a pre-calculated table of values relating ship position relative to the particular satellite.

In practice, there will not be a single reflected path 16. Scatter of the received radio signal will normally take place at the surface of the sea and this will result in the reflected radio wave being received along a number of paths, all of which will be reasonably close to each other. Nevertheless, the nulls in the response curve of the antenna arrangement are of sufficient size to provide very significant attenuation of the signals received by this reflection.

However, it will also be appreciated that the ship itself will be continually changing its attitude relative to the satellite by virtue of the motion of the sea. The angles of the paths 14 and 16 relative to the antenna arrangement will continually be changing.

In order to deal with this, the antenna arrangement could itself be mounted on the ship on a suitable form of stabilising platform intended to ensure that its attitude (relative to the satellite) is relatively unaffected by attitude changing of the ship itself. However, such stabilised platforms are complex and expensive.

It would also be possible to arrange for the distance D between the antenna elements 20, 22 to be continually monitored and varied so as to compensate for the instantaneous changes in attitude of the ship. However, although this is indeed possible, the continual and possibly quite substantial positional variations for the antenna elements may render it unsatisfactory.

Advantageously, therefore, the antenna arrangement includes the phase shifter 34 which provides adjustable electrical phase shift between the signals fed to the receiver on the lines 22 and 24. Adjustment of phase shift between the signals received by a two element array adjusts the angle of maximum response of the array and this has the effect of steering the polar diagram (Fig. 4 or Fig. 5). In this way, therefore, the polar diagram can be continually adjusted so as to provide maximum response along the path 14 and minimal response along a reflected path 16. Because adjustment of the phase shifter 34 does not require mechanical adjustment of the type involved in adjustment of the distance D, it is a comparatively simple matter to arrange for the phase shift to be continually adjusted so as to compensate for the instantaneous changes in the attitude of the ship.

The adjustment of the phase shifter 34 is carried out by the control unit 35. The latter may simply be driven, in an open-loop mode, by output signals from suitable transducing means detecting the attitude of the antenna arrangement. Instead, however, and as will be described in more detail below with reference to Fig. 3, the control unit 35 may operate in a closed-loop mode.

Therefore, the antenna arrangement described provides two adjustments: first, an adjustment of the distance D between the antenna elements to take account of the position of the ship in relation to the satellite, and, secondly, an adjustment of the phase shift between the signals from the two antenna elements to take account of the instantaneous attitude of the ship (and thus of the antenna arrangement).

When the elevation of the satellite relative to the ship is high (above about 50°, say), the required distance D between the antenna elements 20,22 becomes unsatisfactorily small and electrical and possibly even mechanical interference can occur between the elements. However, at such elevations multi-path interference, from reflection of the received signal by the sea, becomes relatively insignificant. Therefore, at such elevations, switch 30 is operated so as to disconnect the antenna elements 20,22 and to replace them by the auxiliary element 34 which is uncompensated for multi-path interference.

Fig. 3 shows a circuit diagram of a modified form of the antenna arrangement of Fig. 2 and parts in Fig. 3 corresponding to those in Fig. 2 are similarly referenced. Fig. 3 shows the screw-jack 40 and the electric motor 42 in dotted outline only.

As shown in Fig. 3, the control unit 35, for adjusting the phase shifter 34 includes an adding unit 50 which receives a control signal on a line 52 which is derived from transducing means sensitive to the pitching and rolling of the ship. In addition, however, the unit 50 receives a correction signal on the line 54 and this control signal is produced by feedback in dependence on the total radio signal received by the antenna arrangement. Thus, the received radio signal is passed through an am-

plifier 56 to receiving circuitry 58 and thence to an output terminal 60. In addition, however, an output is taken from a suitable part of the receiving circuitry on a line 62, such as from the output of its AM detector. This output will be susceptible to variation or fading by virtue of the multi-path interference described above. Assuming that the distance D between the antenna elements 20,22 has been correctly adjusted, any such fading will in the main be due to pitching and/or rolling of the ship and of course indicates that the phase shifter 34 is not correctly adjusted. Any signal on line 62 is therefore detected by detecting unit 64 and activates a control unit 66 to produce the correction signal on line 54. This is added to or subtracted from the control signal on line 52 so as to provide the required adjustment to the phase shifter 34 in a sense and by an amount such as to tend to null the multi-path fading effect.

It will be appreciated that a closed-loop control system could also be employed in the control unit 43 (Fig. 2) to cause additional adjustment of the distance D.

Although the system has been described with particular reference to the reception of radio signals by the ship from the satellite, it will be apparent that it may be employed with advantage when transmitting from the ship to the satellite, in order, again, to avoid multi-path fading of the signal at the satellite. It is found in practice that the circuitry shown in Fig. 3, which uses the received signal to ensure correct adjustment of the phase shifter 34, will provide appropriate adjustment so as to reduce or minimise multi-path fading when transmitting to the satellite.

Although the arrangement has been described as being for use on board ship, it will be appreciated that it may be used for other mobile vehicles, such as ground vehicles or aircraft.

Various modifications can be made. For example, there may be more than two movable antenna elements and the motor 42 may be arranged to vary the spacings between all such movable elements either by moving them individually or in groups. Furthermore, the phase-shifter 34 may be replaced by an arrangement designed to vary the phases between all such elements or beteen some only of them.

CLAIMS

1. An antenna arrangment, comprising a plurality of antenna elements, and driving means for mechanically varying the distance between them whereby to vary the position of the nulls in the response of the antenna arrangement.

2. An arrangement according to claim 1, in which there are two such elements.

3. An arrangement according to claim 1, in which there are more than two such elements and the driving means comprises means for varying the distance between at least two of the elements.

4. An arrangement according to any preceding claim, in which the said driving means comprises an electric motor.

5. An arrangement according to any preceding claim, including adjustable phase-shifting means for adjusting the phase-shift of the electrical signal of at least one of the elements relative to the electrical signal of the or each other said element, whereby to adjust the angle of the response of the elements.

6. An arrangement according to claim 5, including feedback means responsive to the electrical signal produced by the electromagnetic radiation received by the elements for producing a correction signal, and means responsive to the correction signal to adjust the said phase shift to provide a desired response.

7. An arrangement according to any preceding claim, including an additional antenna element and means for switching this element into operation instead of the other said elements.

8. An antenna arrangement for use on a mobile whose geographical position and whose attitude relative to a transmitter are subject to variation, comprising two antenna elements, driving means operable to vary the physical separation between the antenna elements according to the said geographical position, whereby to adjust the position of a null in the reponse of the antenna elements so as to bring that null into at least approximate alignment with a path along which undesired radio signals are expected, phase shifting means connected to phase-shift the electrical signal received from one element relative to that received from the other, and adjusting means operative to adjust the said phase shift in dependence on the said attitude, whereby to vary tha angle of response of the elements.

9. An arrangement according to claim 8, including an additional antenna element and means for switching this element into operation instead of the other said elements.

10. An arrangement according to claim 8 or 9, including feedback means responsive to the total electrical signal received from the elements, so as to detect any undesired variation in that signal, and means responsive to such undesired variations to produce a correction signal for adjusting the phase shift in a direction and by an amount so as to tend to eliminate such variations.

11. An arrangement according to any one of claims 8 to 10, including transducing means responsive to variations in the said attitude for producing a control signal, and means responsive to the control signal for adjusting the said phase shift accordingly.

12. An antenna arrangement, substantially as described with reference to Fig. 2 of the accompanying drawings.

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13. An antenna arrangement, substantially as described with reference to Fig. 5 of the accompanying drawings.

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